Program Announcement to DOE National Laboratories

Greenhouse Gas (GHG) Sequestration Applied Research

1.0 SUMMARY:

The US Department of Energy (DOE), Federal Energy Technology Center (FETC) is seeking applications for research and development activities, beginning in FY 2000, in support of its Carbon Sequestration Program. Proposals are requested to increase and enhance FETC's carbon sequestration research and development activities as described in the FETC Carbon Sequestration Program Plan (http://www.fetc.doe.gov). Research activities by (**A**) multi-performer teams led by National Laboratories on greenhouse gas (GHG) separation and capture and geologic sequestration science and technology, and (**B**) applied research on science-based GHG sequestration options in selected research areas are sought.

From $1,000,000 to $3,000,000 of FY-2000 funding is expected to be available to fund the first year of selected research efforts. Subsequent funding for selected projects will depend upon the availability of future year appropriations, as well as upon satisfactory progress towards project goals and deliverables. Collaborations between industry, university, and DOE national laboratory participants are required for category **A** and encouraged for category **B** under this Program Announcement. Greater priority will be given to those proposals that have cost-sharing.

2.0 SUPPLEMENTARY INFORMATION

Introduction & Background

The concentration of carbon dioxide in the atmosphere is steadily increasing as a result of both land use changes and the combustion of fossil fuels for energy production. Due to the enhanced greenhouse effect caused by increasing concentrations of carbon dioxide and other greenhouse gases in the atmosphere, it is predicted that greater amounts of heat will be retained within the atmosphere, leading to a gradual increase in the surface temperature of the earth.

Reducing the potential risks of human-induced global climate change will require that means to slow the rate of increase in atmospheric carbon dioxide levels be found. Possible strategies that might be used to accomplish this include: 1) more efficient use of energy; 2) greater use of energy from sources that emit less carbon; 3) capture and sequestration of carbon dioxide from power plants and other sources before it is emitted to the atmosphere; and 4) increased carbon sequestration by enhancing the natural capacity of the terrestrial biosphere and the oceans to take up and store carbon. Applied research on strategies 3 and 4 is the subject of this Program Announcement.

In November 1997 The President's Committee of Advisors on Science & Technology (PCAST) published a report on "Federal Energy Research and Development for the Challenges of the Twenty-

First Century". The importance of carbon sequestration research has been underscored by the PCAST report which makes the following recommendations for increasing DOE's R&D for carbon sequestration: **"A much larger science-based CO_2 sequestration program should be developed with the budget increasing from the current $1 million per year [FY 1997] to the vicinity of tens of millions."**

The report further states:

"The R&D should be supported and managed by FE in collaboration with OS and the USGS. It should also collaborate strongly with international efforts, notably those in Japan and Europe. The aim should be to provide a science-based assessment of the prospects and costs of CO_2 sequestration. This is very high-risk, long-term R&D that will not be undertaken by industry alone without strong incentives or regulations, although industry experience and capabilities will be very useful."

More recently, the joint FE and OS draft report "**Carbon Sequestration: State of The Science**," published in April, 1999 offers a broad vision for new options to curb greenhouse gases. The goal of the report is to "... identify key areas for research and development (R&D) that could lead to an understanding of the potential for future use of carbon sequestration as a major tool for managing carbon emissions." The key areas identified for R&D in the draft report are the basis for the Carbon Sequestration Program's research portfolio as described in the FETC **Carbon Sequestration Program Plan,** accessible on the FETC website (http://www.fetc.doe.gov).

The main challenges for the FETC Carbon Sequestration Program are to reduce the cost of sequestration, develop a broad suite of sequestration options, and ensure that long-term sequestration practices are effective and do not introduce any new environmental problems. Associated technical objectives are to: (1) drive down the cost of CO_2 separation and capture from energy production and utilization systems; (2) establish the technical, environmental, and economic feasibility of carbon sequestration using a variety of storage sites and fossil energy systems; (3) determine the environmental consequences of large-scale CO_2 storage; (4) develop opportunities to integrate fossil energy technologies with enhancement of natural sinks; (5) develop innovative technologies that produce valuable commodities from CO_2; and (6) incorporate carbon sequestration processes into advanced energy production and utilization systems.

The Office of Science has recently formed two new centers for Carbon Sequestration Research as part of a "Carbon Management Science Program." The Center for Terrestrial Carbon Sequestration, lead by Oak Ridge National Laboratory, will develop the scientific understanding to evaluate the feasibility of environmentally sound strategies for enhancing carbon sequestration in terrestrial ecosystems. The Center for Ocean Sequestration, headed up by Lawrence Berkeley and Lawrence Livermore National Laboratories, will address (1) enhancing sequestration through fertilization of the ocean with nutrients and (2) direct injection of CO_2 into the deep ocean. Through these collaborative partnerships, the

Centers will conduct basic research, assess existing knowledge and test the feasibility of environmentally sound strategies for enhancing carbon sequestration in land and oceanic systems.

The FETC Carbon Sequestration Program seeks to build on, collaborate with, and apply basic activities being conducted in the OS Centers programs. FE and OS are planning a carbon sequestration technology development roadmapping effort to further define research pathways identified in the draft **State of Science** report and collaborating on developing technology assessment tools. The goal of both programs is to conduct the full spectrum of necessary R&D to define the potential of carbon sequestration as a major tool for managing carbon emissions.

Goals and Objectives

Recognizing the breath of expertise and capabilities of the DOE National Laboratories, a primary purpose of this Program Announcement is to seek projects that increase and enhance FETC's carbon sequestration research and development activities. In addition to Memorandum of Understanding (MOU) and other agreements, future Program Announcements will establish a systematic approach to facilitate programmatic planning for incorporating the research activities of the DOE National Laboratories, and significantly increases the likelihood of success in developing cost-effective carbon sequestration technologies. It is intended that as the Carbon Sequestration Program grows, the National Laboratory component of the Carbon Sequestration Program will also increase and will be focused on topics and priorities to be defined in future Program Announcements.

National Laboratory research activities in categories **A** and **B** to be funded in FY-2000 will be selected based upon this Program Announcement. Hence, ongoing FY-1999 Laboratory projects which intend to seek continued funding in FY- 2000 MUST respond to this Program Announcement. Projects addressing categories **A** or **B** must submit FWP by November 1, 1999. The timing and extent of future program announcements will be determined by the progress of on-going research activities and funding availability.

FETC has announced a Program Solicitation, "Research and Development of Technologies for the Management of Greenhouse Gases", that seeks proposals from private industry, academia, small and large businesses, and research institutes in the research areas described herein. It is expected that the research activities selected from the Program Solicitation and this Program Announcement will significantly accelerate the development of a broad portfolio of sequestration options and present the best opportunities for meeting the Carbon Sequestration Program goals.

Technical Areas of Interest

Proposers may submit research proposals for any topic area, for more than one topic area, and for research activities that encompass more than one topic area. An example of a proposal encompassing more than one topic area could involve both capture and use of CO_2. Separate proposals for each

respective topic area must be submitted if a proposer desires to submit multiple proposals.

A: **Applied research on GHG separation and capture and geologic sequestration science and technology by National Laboratory-led multi-performer teams**

General

The projects that result from **A** will be funded as pilot programs, subject to availability of funds and project performance. Two topic areas have been chosen for this pilot program: (1) GHG Capture and Separations Science and Technology; and (2) Geologic Sequestration Science and Technology. In category **A**, FETC is seeking proposals describing significant research activities geared towards meeting the programmatic goals of the Carbon Sequestration Program in a timely fashion. It is the intent that Teams, consisting of multiple national laboratories, extramural groups including industry, and in particular the university research community, focus, coordinate, manage, and conduct science-based carbon sequestration applied research.

1. GHG Capture & Separations Science and Technology Focus Area

Reducing the costs of GHG capture and separation is a major barrier to achieving cost-effective sequestration. The objectives of this Focus Area include the reduction of both the capital and energy costs associated with GHG, especially CO_2, capture and separation from large point sources. Opportunities for significant cost reductions exist since very little R&D has been devoted to CO_2 capture and separation technologies. This topic area focuses on research activities that lead to evolutionary improvements in existing CO_2 capture systems and also explores revolutionary new capture and separation concepts.

The specific performance requirements for cost-effective technologies are strongly dependent upon the storage or reuse/conversion "destination" of the captured GHGs, and the other associated emissions. Fossil fuel energy systems that integrate utilization with CO_2 separation and capture and "one box" concepts that combine CO_2 capture with reduction of criteria-pollutant emissions are also desired. Proposals must address how these "requirements-in-use" will be established and used to guide the team activities.

Research pathways and approaches which have multiple applications and use under a broad range of scenarios are desired. The integration of concepts and projects, including criteria and priorities for project selection, must be clearly established to allow development of costs associated with the capture and separation technology.

2. Geologic Sequestration Science & Technology Focus Area

Geologic sequestration incudes a broad set of target geologic formations, with initial emphasis

on depleting oil and gas reservoirs, and deep unmineable coal seams, followed closely by deep saline/brine formations. Concepts such as mineral carbonization are also included in target set. Team proposals in this topic area must demonstrate how applied science knowledge and technologies which crosscuts all these formation destinations will be coordinated to achieve maximum benefits, as well as how special needs unique to specific formation types will be addressed. Proposals should address how both advanced techniques applicable to traditional oil and gas exploration and extraction industry needs will be addressed, and how science and technologies from outside these fields will be brought to bear.

Proposals should address research to determine the long-term environmental acceptability, and to measure and verify the amounts of carbon that are being sequestered. They should also address research to define the limits of acceptable environmental, cost and performance factors, and the acceptable compositions or "quality" of the streams to be sequestered for a specific application (EOR, ECBM, Saline/Brine formations, etc.).

B: Applied research on science-based GHG sequestration options in selected research areas

General

While the emphasis of this category is on the research priorities contained in the Carbon Sequestration Program Plan, other innovative novel ideas and concepts that have significant GHG sequestration potential are also desired. Each proposal should address how it draws upon the unique capabilities of the Laboratory and the project team, past and ongoing fundamental science funded by the Office of Science or other DOE sources, and how research results will be transferred to practice. Teaming with industry is encouraged. Leveraging of funding, cost-sharing and collaboration with industry and university partners is encouraged. Each proposal should address how the results of the research would contribute to the goals of the Carbon Sequestration Program. In addressing this, a systems context must be adopted to determine the benefits, identify uncertainties, and evaluate the utility of the technology for GHG sequestration. This systems evaluation must address both the potential benefit to the particular application(s) in which results would be used, the degree to which it has the potential for widespread use versus niche uses, and the extent the technology meets the Carbon Sequestration Program Goals.

Selected Research Areas

1. <u>Opportunities for Integration of Terrestrial Sequestration (trees, vegetation, soils) with Fossil Fuel Production and Use.</u> Proposals should demonstrate cooperation and collaboration with organizations which may become users of the results, as well as with other research funding and performing entities such as the U.S. Forest Service, other elements of USDA, and other Federal and State Agencies. Opportunities to achieve results by innovative, multi-disciplinary

research that might not otherwise occur are also of high interest. Examples are:

— Applied research geared towards providing fossil fuels producers (coal, oil, gas extraction and processing) and users (power generators and other point sources) opportunities to integrate operations with cost-effective, non-point-source terrestrial sequestration.

— Research on how byproducts from fossil fuel production or use could become part of a cost-effective terrestrial sequestration approach.

2. Ocean Sequestration. The objectives of this topic area include identifying the costs, environmental acceptability and effectiveness of sequestering CO_2 in the oceans. Technology exists for the direct injection of CO_2 into deep areas of the ocean; however, the knowledge is not adequate to optimize the costs, determine the effectiveness of the sequestration, and understand the resulting changes in the biogeochemical cycles of the ocean. Also a better understanding of the ecological impact of injecting CO_2 into the deep ocean is needed.

   FETC is currently engaged in an international collaborative applied research program on deep ocean injection of CO_2. The international project is focused on obtaining the necessary applied science and technology knowledge base to determine the environmental, economic, and performance acceptability of the deep ocean injection research pathway. Further information on this collaboration is contained in the **State of Science** draft report and the FETC Carbon Sequestration Program Plan. High priority emphasis will be given to proposals which complement, supplement or otherwise contribute to the goals of that international collaboration.

   Research that involves collaboration and cooperation with other ocean research programs to produce results critical to program goals is strongly encouraged. FETC is interested in receiving research proposals that develop and optimize systems to deliver CO_2 to injection sites and potential nutrients for dispersal in the ocean, reliable estimates of the cost and effectiveness of ocean sequestration, and concepts for converting CO_2 to other forms (e.g., carbonates, clathrates) that are stable in the ocean or on the ocean floor.

3. GHG Capture and Separations & Geologic Sequestration Science & Technology This selected research topic is also included in category **A**. Research proposals are sought for unique, high payoff, high risk projects which may be beyond the scope of what would be proposed as part of a category **A** projects. It is the intent of this Program Announcement to emphasize research in this selected research topic by a multi-performer team that includes industry to facilitate technology transfer, speed up commercialization, and maximize leveraging of programmatic funds. Proposals should address why research in this selected research topic is being proposed in category **B**.

4. Advanced Chemical, Biological and Reuse & Other Novel Concepts. Recycling or reuse of CO_2 from energy systems would be an attractive alternative to storage of CO_2. The goal of this topic area is to reduce the cost and energy required to chemically and/or biologically convert CO_2 into either commercial products, or stable compounds that are inert and long-lived. Objectives include the development of novel chemical reaction pathways and biological systems that enable CO_2 to be converted to useful products or chemical species that are more easily stored, and other novel concepts.

3.0 PERIOD OF PERFORMANCE

FETC suggests, but does not require, that proposals offer a separate task and corresponding cost structure that permits partial awards if appropriate. For category **A**, project duration is expected to be up to three years, and for category **B**, up to two years. It is anticipated that one project will be awarded for category **A**, GHG separation and capture science and technology focus area, and one project will be awarded for category **A**, geologic sequestration science and technology focus area. Multiple project awards are anticipated for category **B**.

Periods of performance should coincide with fiscal year budget periods. Project continuation shall be subject to (1) funds availability; (2) sufficient progress in the research effort; (3) sufficient progress towards completing the objectives in accordance with a mutually agreed upon management plan; and (4) submission of timely and informative reports.

4.0 REPORTING

Successful applicants selected in category **A** will be required to submit a Management Plan that includes a description of how a proposed Team would be organized, managed, and operated. The Management Plan must also include a description of how needed expertise from outside the proposed Team, such as academically-based researchers, would be integrated into the research performed by the Team, and how the results of scientific research activities funded by the Office of Science and others will be transferred to the applied research activities included in the Carbon Sequestration Program.

Successful applicants selected in both categories **A** and **B** will be required to submit quarterly Technical Reports, and comprehensive Final Reports.

5.0 FIELD WORK PROPOSAL EVALUATION AND SELECTION

Qualification Criteria: Field work proposals must meet the following two criteria to be considered for award.

Criterion 1: Category **A** proposals must include industrial participation in the proposed research activities.

Criterion 2: Category **A** proposals must include two or more National Laboratories as members of the multi-performer teams.

Evaluation Criteria: The following four (4) criteria will be used in the technical evaluation of the field work proposals.

Criterion 1: Research Concept and Plan (40%)

Applications shall be evaluated considering: a) the responsiveness of the proposal to research priorities identified in the "FETC Carbon Sequestration Program Plan" and "Carbon Sequestration: State of The Science" draft report, especially how the proposed outcomes will benefit the Carbon Sequestration Program goals; b) the adequacy of the statement of objectives (including a review of work completed to date); c) the technical feasibility of the proposed work ; and d) the appropriateness of the schedule (principal milestones, decision points, and time for each task).

Criterion 2: Applicant/Team Capabilities and Facilities (20%)

Capabilities and facilities shall be evaluated considering: a) ability to assemble and manage a multi-disciplined team with research experience and qualifications in the proposal subject area; b) knowledge of past advanced developments in the work proposed; c) the availability of equipment, laboratory and demonstration facilities, analytic support and other necessary resources for performing the work proposed; and d) the planned level of manpower to complete the research.

Criterion 3: Industrial Involvement (20%)

Industrial involvement shall be evaluated considering: a) the level of participation, the number of industry partners, and the level of participant cost-sharing; and b) identification of, and commitment to, a viable plan to transfer the technology to industry at the earliest practicable time.

Criterion 4: Other Participant (Federal, State, or Local Government Agencies, Universities and/or Academic) Involvement (20%)

Federal, State, or Local Government involvement shall be evaluated considering collaborative activities that further sequestration technology development. University/Academic involvement shall be evaluated considering the level of participation by a university or other academic institution to: a) support research and development tasks; b) educate technical professionals; and/or c) facilitate communication to help transfer technology; or f) educate the public regarding the benefits of sequestration technology.

6.0 PROGRAMMATIC CONSIDERATIONS In conjunction with the evaluation results and rankings of individual applications, FETC shall make selections for negotiations and planned awards from among the highest ranking applications, using the following six (6) programmatic considerations.

(1) The desire to select field work proposals addressing the research priorities identified in Section 2.0.

(2) The desire to select field work proposals that offer significant GHG sequestration potential, identify and describe activities to minimize possible environmental impacts, and present the lowest-cost GHG sequestration options.

(3) The desire to select field work proposals that offer particularly innovative, yet technically feasible GHG sequestration approaches.

(4) The desire to select field work proposals that include University/Academic involvement as an integral part of the proposed project by their directly performing research and development activities, educating technical professionals, facilitating technology transfer and educating the public to facilitate acceptance GHG sequestration technologies.

(5) The desire to select a portfolio of research projects that are balanced with respect to technological application, sources of GHG emissions, and GHG sequestration potential.

7.0 SUBMISSION OF APPLICATIONS

One original and six (6) copies of each field work proposal shall be submitted by 3:00 P.M. EST on November 1, 1999.

Field work proposals shall be submitted to:

US Department of Energy
Federal Energy Technology Center
PO Box 10940
Pittsburgh, PA 15236
Attention: Charles E. Schmidt
Telephone: 412/386-6090
E-mail:schmidt@fetc.doe.gov